

# PATENT SPECIFICATION

NO DRAWINGS

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## COMPLETE SPECIFICATION

### Improvements in or relating to Weighing Apparatus

We, ESSO RESEARCH AND ENGINEERING COMPANY, a Corporation duly organised and existing under the laws of the State of Delaware, United States of America, of Elizabeth, New Jersey, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to weighing apparatus and is particularly concerned with balances, known as micro-balances, for weighing very small quantities, more particularly for measuring small changes in weight of samples which may be in severe environments.

The invention is an improvement or modification of the invention described in Patent Specification No. 986,011.

According to the present invention, a weighing apparatus comprises a responsive element having piezo-electric or magneto-strictive properties to which a sample of the material to be weighed is firmly attached, means for causing the responsive element to oscillate and means for measuring changes in the oscillation characteristics of the element due to the mass of the sample or to changes in the mass of the sample.

According to a preferred form of the invention, the apparatus comprises two of the said responsive elements maintained in the same environment, to one of which the sample is firmly attached, and means for measuring changes in the difference between the oscillation characteristics of the two elements due to changes in the mass of the sample.

In a preferred form of the invention, the oscillation characteristic which is measured is the frequency of the oscillation, but other characteristics such as amplitude may also be utilised.

Preferably each responsive element is a piezo-electric crystal, e.g. a quartz crystal.

A responsive element having piezo-electric or magneto-strictive properties vibrates in a manner which is influenced by the mass of the element and so also by the mass of any substance deposited on the surface of the element. The effect of changes in mass of a substrate substance deposited on the surface of such an element on the oscillation characteristics of the element, due to interaction between the substrate and its environment, has been described in Patent Specification No. 986,011, where such effects are made use of in the detection and analysis of components in gas streams.

In the present invention, changes in the oscillation characteristics of the responsive element, or in the difference between the oscillation characteristics of two responsive elements, are used to measure the mass of a substance, or changes in the mass of a substance, deposited on the element.

Thus, for example, the apparatus of the present invention may be used to weigh very small quantities of material by comparing the oscillation frequency of a responsive element with and without the material deposited thereon.

The apparatus is particularly suitable for use in thermo-gravimetric analysis since a plot of frequency against temperature will show losses or gains of weight of the material as the temperature is varied in a particular environment and in accordance with a predetermined programme. Because of the sensitivity of the apparatus, very small quantities of the material (less than  $10^{-4}$  g.) may be used, so that much more rapid temperature programmes can be used than in conventional apparatus.

By using two responsive elements in the

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same environment, on one of which the material is deposited, changes in frequency due to the effect of temperature on the elements themselves will be eliminated and changes in the difference of frequency between the two elements will indicate only changes in the mass of the material. By choosing suitable operating parameters, differential thermal analyses may also be carried out. Since the quantity of material used may be very small, very sharply defined thermo-gravimetric profiles and thermal analysis peaks may be obtained.

If the temperature co-efficient of frequency of the responsive element has been determined, then the absolute frequency of the element without any material deposited thereon may be used as an accurate measure of the temperature of the environment. Thus all the information required for thermo-gravimetric or differential thermal analysis curves can be obtained from a simple two-element system.

#### WHAT WE CLAIM IS:—

1. A weighing apparatus comprising a responsive element having piezo-electric or magneto-strictive properties to which a sample

of the material to be weighed is firmly attached, means for causing the responsive element to oscillate and means for measuring changes in the oscillation characteristics of the element due to the mass of the sample or to changes in the mass of the sample.

2. An apparatus according to claim 1, comprising two of the said responsive elements maintained in the same environment, to one of which the sample is firmly attached, and means for measuring changes in the difference between the oscillation characteristics of the two elements due to changes in the mass of the sample.

3. An apparatus according to claim 1 or claim 2 in which the oscillation characteristic which is measured is the frequency of the oscillation.

4. An apparatus according to any preceding claim in which each of said responsive elements is a piezo-electric quartz crystal.

5. A weighing apparatus substantially as hereinbefore described.

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